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(54) **Combination weighing with
volumetric metering**

(57) A combination weighing machine has a plurality of weighing units and is arranged to load at least one of the weighing units 14_i with articles having a predetermined volume, to compare the weight signal from this weighing unit with a predetermined reference weight signal, and to deliver the articles of the predetermined weight when their weight is greater than the reference weight. Combination operation of said weight signal and the weight signals from the other weighing units 14_i is used to select a combination having a weight greater than the reference weight from the combinations including the weight of the articles of the predetermined volume for delivery, for the purpose of forming batches of articles each having volume and weight greater than predetermined values.

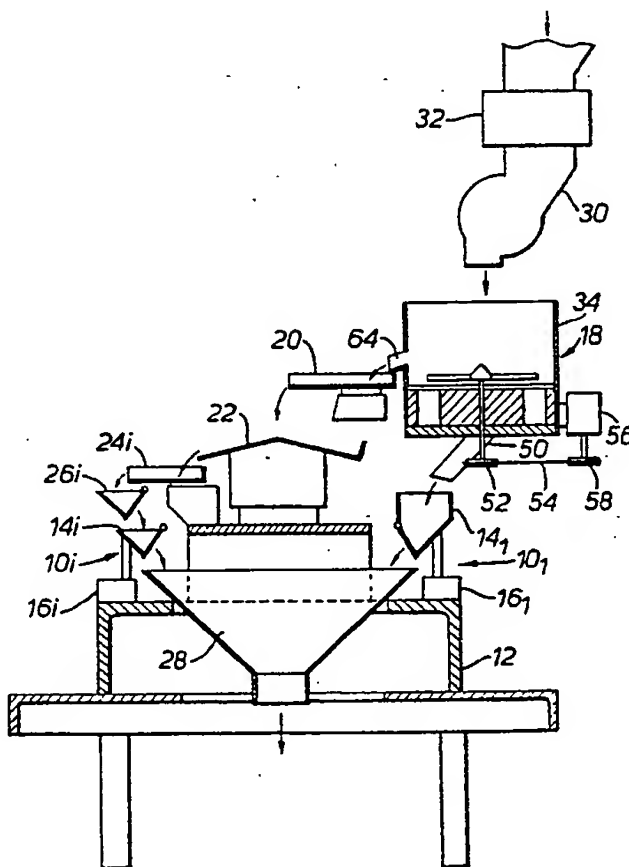


FIG.1.

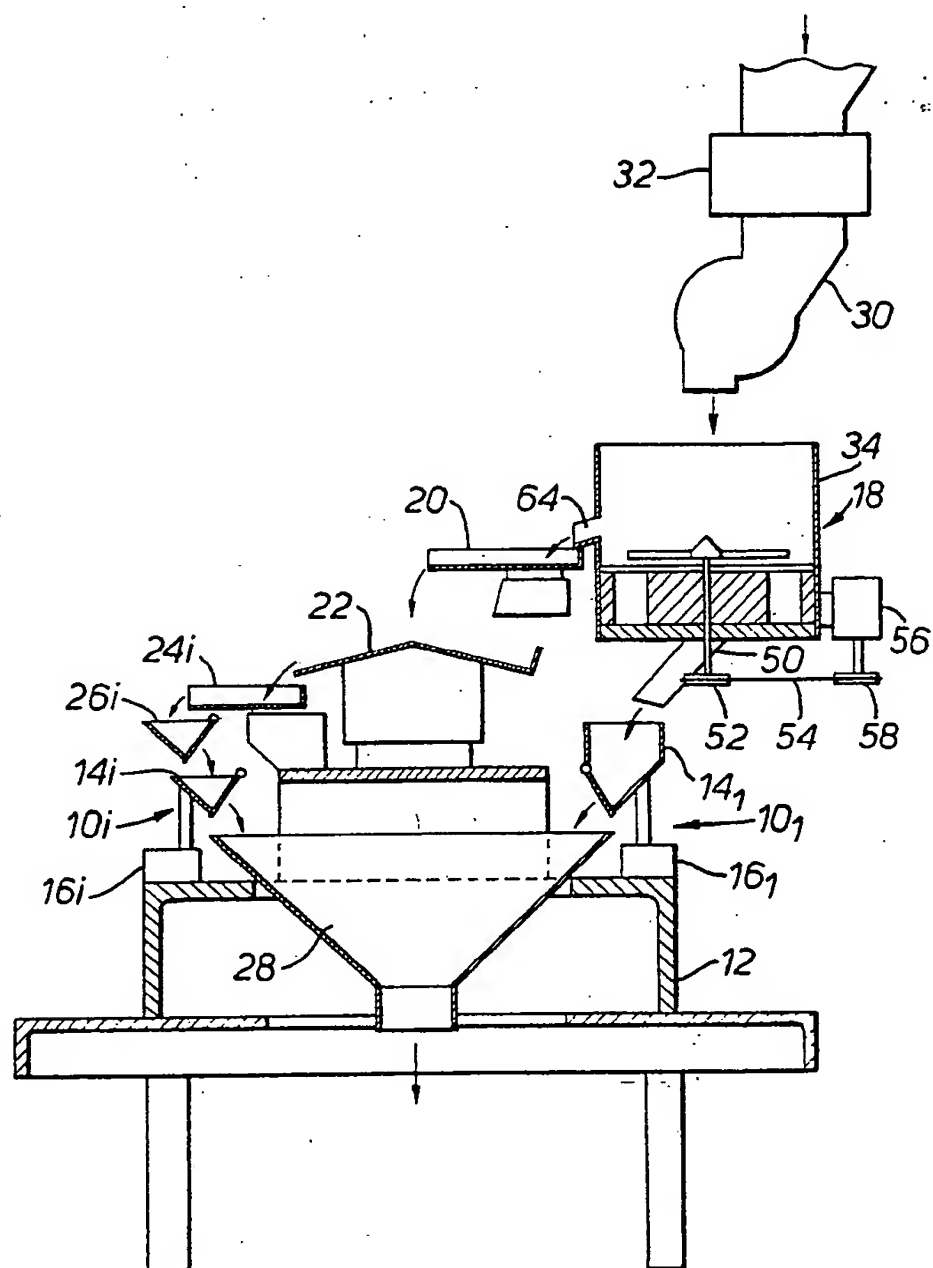


FIG. 1.

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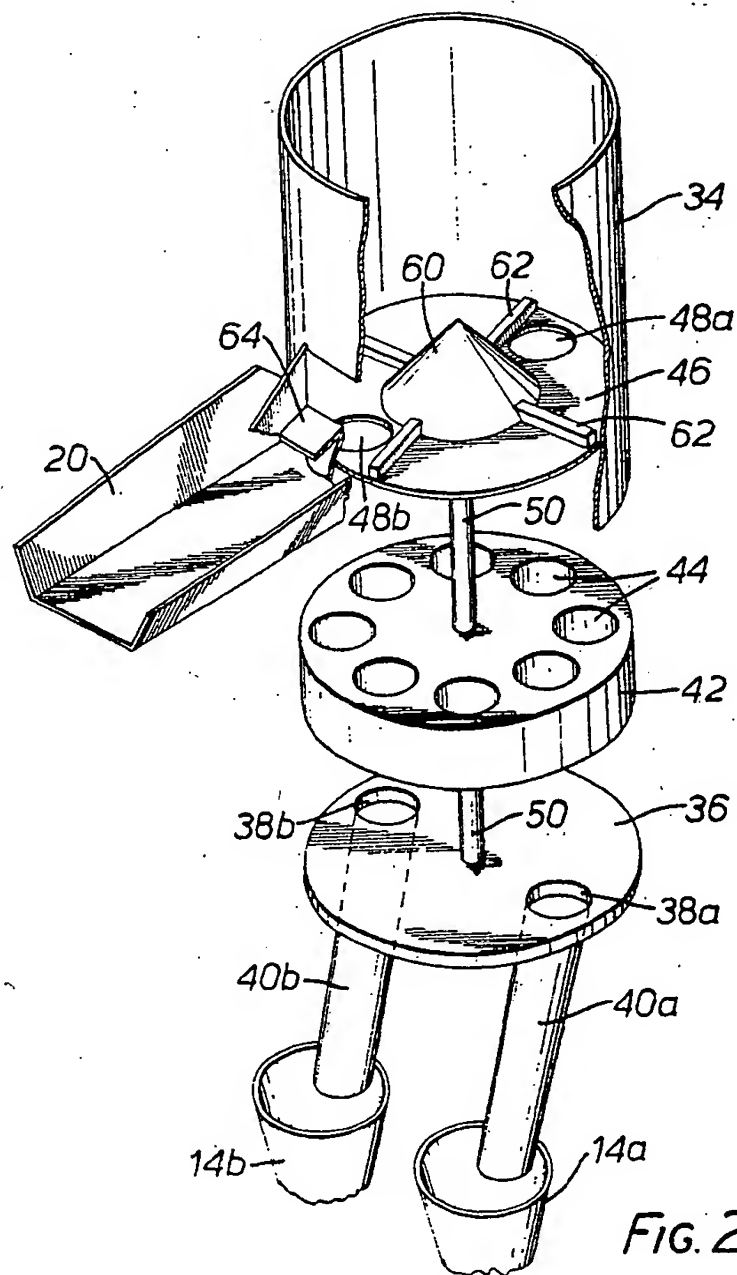


FIG. 2.

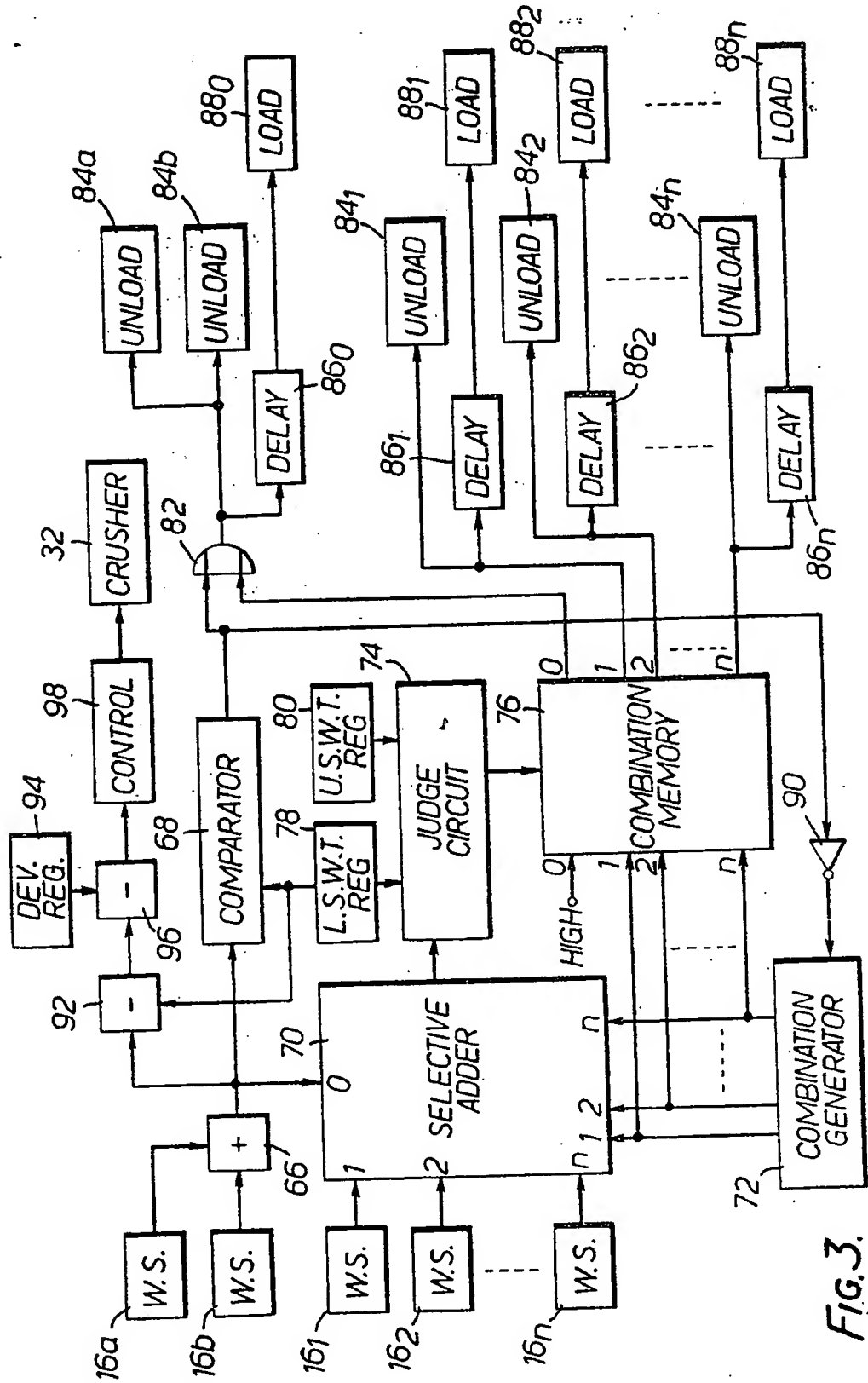


Fig. 3.

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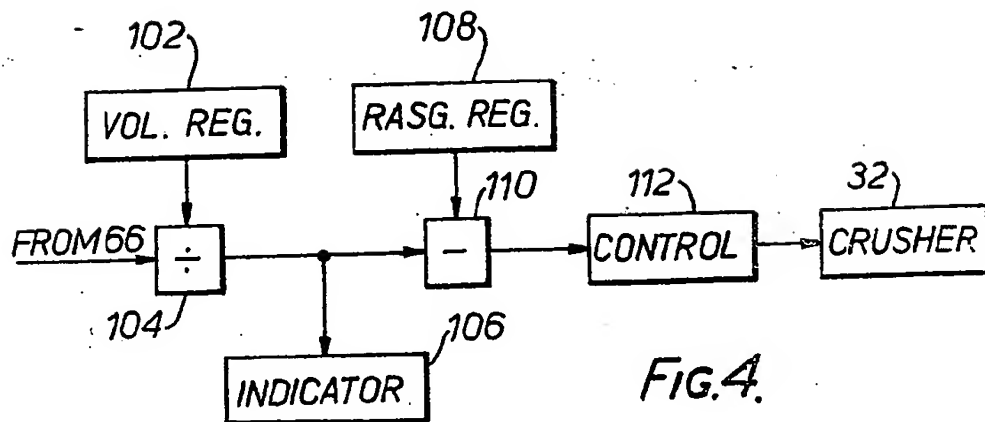


FIG. 4.

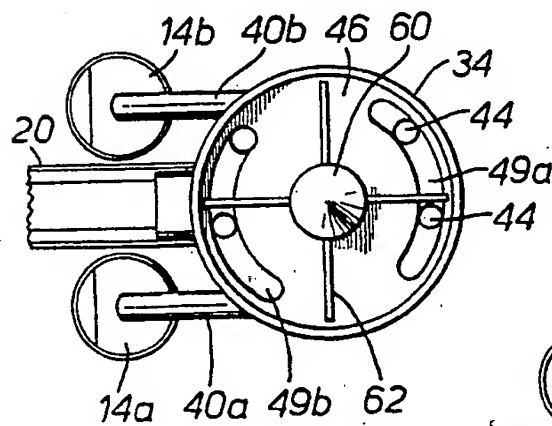


FIG. 6.

FIG. 7.

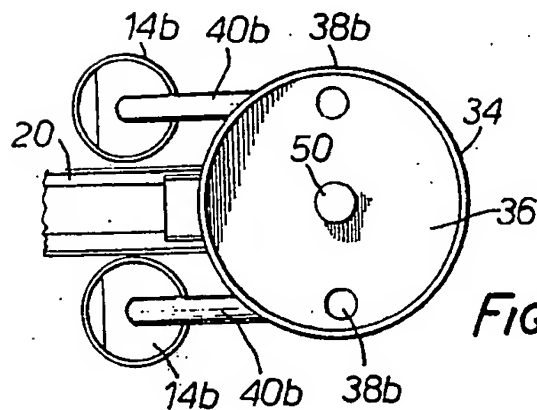
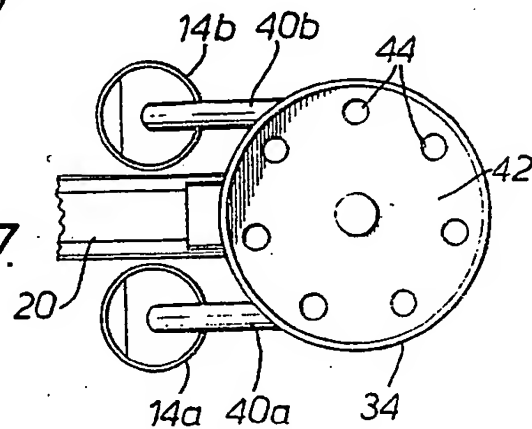


FIG. 8.

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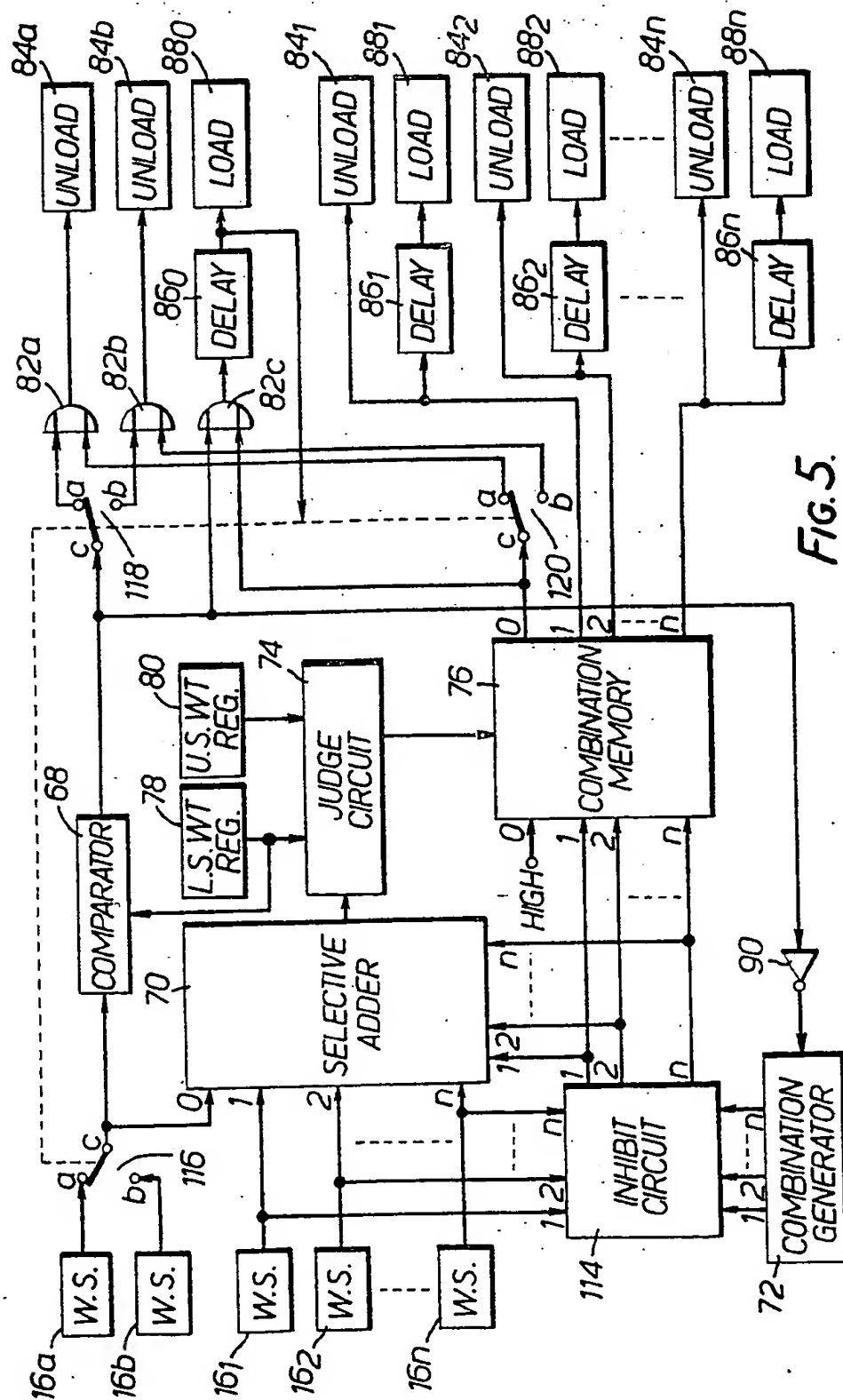


FIG. 5.

SPECIFICATION

Combination weighing machine having volume confining function

5 This invention relates to a combination weighing machine, especially, to such machine for delivering batches of articles having volume and weight greater than predetermined values each.

10 In case of packing flaky articles such as cornflakes in bags, it is sometimes requested that the articles in each bag are above a predetermined value not only in their weight, but also in their volume. Because, such articles are fragile and those crushed are less in volume and lower in commercial value even if their weight is acceptable. As disclosed, for example, in U. S. Patent No. 3,939,928, the combination weighing machine is arranged to weight articles by a plurality of weighing units at the same time and combine the resultant weight value in various fashion to select a combination the total weight of which satisfies a predetermined condition. However, the selected combination can not be loaded with volume condition in general, even though it satisfies the weight condition. U. S. Patent No. 4,388,975 discloses a special combination weighing machine which can cause at least one of a plurality of weighing units to participate always in the selected combination. This machine intends to mix some specific kind of articles always in the selected combination. In such case as above, where the selected combination must have a volume greater than a predetermined value, the object can be attained by loading the weighing unit participating always in the selected combination with articles which have previously been measured out to have about a predetermined volume. In this case, however, if the articles having been measured out satisfy the weight condition by themselves, the object can be attained only by delivering these articles and there is no need of effecting the original operation of combination weighing machine, such as combination arithmetic, to waste an unwanted time.

50 Accordingly, an object of this invention is to provide a combination weighing machine which can weigh out articles having a volume above a predetermined value and satisfying a predetermined weight condition, without waste of time as above.

55 While the combination weighing machine according to this invention includes, as a conventional combination weighing machine, a plurality of weighing units for weighing articles each to produce corresponding weight signals, means for effecting combination operation of the weight signals, means for comparing the resultant sum weights of combinations with a predetermined weight condition to decide whether they are acceptable or not, and

means for unloading and loading those weighing units having participated in the accepted combination, it is further arranged, as a feature of this invention, to cause at least one of the plurality of weighing units to participate always in the selected combination, as in the device disclosed in the above U. S. Patent No. 4,388,975, and also provided with means for comparing the weight signal from the weighing unit participating always with the above weight condition to decide its acceptability and, if acceptable, unloading and loading this weighing unit but, if unacceptable, actuating the above operation means, in addition to the former comparing means.

Other objects and features of this invention will be described in more detail hereinafter with reference to the accompanying drawings.

In the drawings:

85 *Figure 1* is a partially sectional schematic side view representing a mechanical configuration of an embodiment of the combination weighing machine according to this invention;

90 *Figure 2* is a partially broken-away dislocated perspective view representing a constant volume feeding device used in the embodiment of Fig. 1;

95 *Figure 3* is a block circuit diagram representing an electrical configuration of the embodiment of Fig. 1;

Figure 4 is a block diagram representing a modification of a part of the circuit arrangement of Fig. 3;

100 *Figure 5* is a block diagram representing an electrical configuration of another embodiment of the combination weighing machine according to this invention; and

105 *Figures 6, 7 and 8* are plan views representing a structure of another embodiment of the constant volume feeding device of Fig. 2.

Throughout the drawings, the same reference numerals are given to equivalent structural components.

Referring to Fig. 1, the combination weighing machine includes weighing units 10_a, 10_b, 10_c, 10_d, . . . 10_n, . . . 10_n arranged circularly on a frame 12 and provided with weighing hoppers 14_a, 14_b, 14_c, 14_d, . . . 14_n and weight sensors 16_a, 16_b, 16_c, 16_d, . . . 16_n, respectively. Two of these weighing units 10_a and 10_b are provided with weighing hoppers 14_a and 14_b, respectively, which are substantially greater in volume than those of the other units and, as described later, loaded with articles having a predetermined volume by a common constant volume feeding device 18. The articles are also fed from the feeding device 18 through a vibration conveyor 20 to the central portion of a conical distribution feeder 22, and further supplied through vibration conveyors 24_a, . . . 24_c, . . . 24_n and holding hoppers 26_a, . . . 26_c, . . . 26_n to the weighing hoppers 14_a, . . . 14_c, . . . 14_n, respectively. A common collection chute 28 is located under the weighing hoppers 14 for collecting the

articles discharged from the selected weighing units to deliver them to a packing machine (not shown). Supply of the articles to the constant volume feeding device 18 is effected by a feeding machine 30 provided with a crusher 32 to be described later.

As shown in detail in Fig. 2, the constant volume feeding device 18 includes a cylindrical tank 34 having a bottom plate 36 in which a pair of through-holes 38_a and 38_b are formed at 180° interval. The holes 38_a and 38_b communicate with the weighing hoppers 14_a and 14_b, respectively, by tubular chutes 40_a and 40_b. On the bottom plate 36, there is a concentric thick volumetric disc or cylinder 42 having even numbers (eight, in this embodiment) of cylindrical through-holes 44 which can register with the holes 38_a and 38_b of the bottom plate 36. The volumetric disc 42 is designed such that the volume of each hole 44 is equal to a half of the lower threshold of the abovementioned predetermined volume of articles. On the volumetric disc 42, there is a top plate 46 having a pair of through-holes 48_a and 48_b which are similar to the holes 38_a and 38_b of the bottom plate 36 but angularly displaced therefrom by about 90°. The bottom and top plates 36 and 46 are fixed to the tank 34, while the volumetric disc 42 can move slidingly between the both plates. The volumetric disc 42 is fixed at its center to a shaft 50 and a pulley 52 fixed to the lower end of the shaft 50 is coupled through a belt 54 to a pulley 58 of a motor 56 (see, Fig. 1). The motor 56 includes a suitable reduction gear device and rotates the volumetric disc 42 by one pitch (the angle between the adjoining holes 44) in response to a driving signal which will be described later. A conical cap 60 having four vanes 62 is fixed to the top of the shaft 50 for rotating with the disc 42 to stir the articles in the tank 34 for preventing retardation. The side wall of the tank 34 has an exit port 64 just above the top plate 46, which opens just above the vibration conveyor trough 20. Accordingly, when the shaft 50 is driven in such a state that a suitable amount of articles have been fed in the tank 34 from the feeder 30, the vanes 62 rotate with the volumetric disc 42 to stir the articles in the tank 34 and the articles fall in the volumetric holes 44 when they register with the holes 48_a and 48_b of the top plate 46 and then fall in the weighing hoppers 14_a and 14_b through the chutes 40_a and 40_b when the holes 44 register with the holes 38_a and 38_b of the bottom plate 36. At the same time, the articles in the tank 34 stirred by the vanes 62 fall down onto the conveyor trough 20 from the exit port 64 by the gravity and are successively conveyed to the dispersion feeder 22.

Referring to Fig. 3, weight signals generated by the weight sensors 16_a and 16_b of the weighing units 10_a and 10_b are summed by

an adder 66 and the resultant sum is applied to a comparator 68. On the other hand, weight signals generated by the weight sensors 16₁, 16₂, ... 16_n of the weighing units 10₁, 10₂, ... 10_n are selectively summed by a selective adder circuit 70 controlled by combination control signals generated by a combination generator 72 and the resultant sum weights are successively supplied to a judge circuit 74. The combination generator 72 has outputs 1, 2, ... n corresponding to the weight sensors 16₁, 16₂, ... 16_n, which are coupled also to corresponding inputs of a combination memory 76. In addition to these inputs, the combination memory 76 has a further input terminal 0 which is always provided with a logic high level signal from a suitable source (not shown). The comparator 69 compares the sum weight from the adder 66 with a lower threshold weight (the allowable lower limit of the combined weight) preset in a lower threshold weight register 78 and, when the former is greater than the latter, produces a logic high level signal which is applied through an OR gate 82 to unloading devices 84_a and 84_b for the weighing hoppers 14_a and 14_b. The unloading device is an electromechanical device which responds to the high level signal to open the gate of the corresponding weighing hopper for a predetermined time to discharge its content and may be of any configuration known to those skilled in the art. The high level signal is also applied through the OR gate 82 and a delay element 86₀ to a loading device 88₀. The loading device 88₀ includes the motor 56 of the constant volume feeding device 18 and, as described previously, responds to the input signal to rotate the volumetric disc 42 by one pitch to supply new articles which have been measured out by volume to the unloaded weighing hoppers 14_a and 14_b. The delay element 86₀ is used for setting a time difference between the unloading and loading operations and may be of any type known to those skilled in the art.

When the sum weight from the adder 66 is less than the lower threshold weight, the comparator 68 provides a logic low level signal through an inverter 90 to the combination generator 72 as its start signal. In response thereto, the combination generator 72 initiates its operation and supplies its output signals to the selective adder circuit 70. Thus, the selective adder circuit 70 also initiates arithmetic operation under control of the output signals of the combination generator 72. In addition to the weight signals from the weight sensors 16₁, 16₂, ... 16_n, the sum weight from the adder 66 is also applied to the selective adder circuit 70 so that the input from the adder 66 participates always in any combination regardless of the output format of the combination generator 72. This circuit arrangement is described in detail in the

above U. S. Patent No. 4,388,975 and will not be described further. The combined sum outputs of the selective adder circuit 70 are compared with the lower threshold weight
 5 preset in the lower threshold weight register 78 and with an upper threshold weight preset in an upper threshold weight register 80 in the judge circuit 74 which provides an acceptance signal to the combination memory 76
 10 when any combined sum falls between the both thresholds. The combination memory 76 stores the current input format and also supplies corresponding output signals directly to the unloading devices 84₁, . . . 84_n, and
 15 through delay elements 86₁, . . . 86_n to loading devices 88₁, . . . 88_n. These unloading devices, delay elements and loading devices operate similarly to the abovementioned 84₁, 84_n, 86₁ and 88_n and respond to logic high level input signals to unload and load the corresponding weighing units. In this case, the weighing units 10₁ and 10_n are also unloaded and loaded together as described previously, since a high level output signal is
 25 applied then to the OR gate 82 from the output terminal 0 of the combination generator 72.

Thus, each batch of articles collected in the collection chute of Fig. 1 and then delivered
 30 to the packing machine is rendered to have a volume equal to or greater than the specified value and a weight within the specified range.

Although, in the above embodiment, two weighing units (10₁ and 10_n) were shown to be fed from the constant volume feeding
 35 device 18, this is only for illustrative purpose and has no special significance. A single constant volume weighing unit may be used and it may be rather economical since the adder
 40 66 can be omitted. However, it is also true that the more the constant volume weighing units, the less the volumetric error. The volumetric error may be caused by insufficient filling of the volumetric holes 44 of the volumetric disc 42. In order to avoid it, the holes
 45 48₁ and 48_n of the top plate 46 may be substituted with arcuate slots 49₁ and 49_n, which can cover a plurality of holes 44, respectively, as shown in Fig. 6. Although, in
 50 the above embodiment, the combined weight was assumed to be allowable if it fell within the predetermined range, it is also possible to select out such a combined weight which is equal or nearest to the lower threshold
 55 weight. The configuration of the judge circuit 74 for this purpose is disclosed, for example, in U. S. Patent No. 4,416,341 or U. K. Patent No. 2,089,153. In general, the target weight condition can be predetermined arbitrarily by designing the comparator 68, judge
 60 circuit 74 and their associated circuits so as to meet the requirement and all devices including such modified circuit arrangement is also within the scope of this invention.

65 When the shape and/or size of the articles

are indefinite, a large variance is anticipated in the weight of each batch delivered from the constant volume feeding device 18. When it is too small (that is, the apparent specific gravity is too small), a greater amount of articles should be added during the combination weighing operation and this may result in such a trouble that no normal prescribed packing can be effected by the associated packing
 70 machine. In order to avoid this trouble, the feeding machine 30 of Fig. 1 is provided with a crusher 32 for crushing the articles adequately to increase the apparent specific gravity thereof. In order to control this crusher 32
 75 automatically, the arrangement of Fig. 3 includes further a crusher control device comprising a subtracter 92 receiving the outputs of adder 66 and upper threshold weight register 78, a deviation register 94 for storing a
 80 predetermined weight deviation threshold, a second subtracter 96 receiving the outputs of deviation register 94 and subtracter 92, and a control circuit 98 receiving the output of subtracter 96. As self-understood, subtracter
 85 92 calculates every cycle the deviation of the weight of the predetermined volume of articles from the lower threshold weight and subtracter 96 calculates the deviation of the above-calculated deviation from the predetermined threshold deviation. The control circuit
 90 98 responds to this deviation from the threshold deviation to provide an adequate control signal for controlling the operation time and/or energy of the crusher 32, depending
 95 upon its structure.

Another embodiment of crusher control device is shown in Fig. 4. This device includes a volume register 102 for storing the total volume of the articles fed to the constant volume
 100 weighing units, a divider 104 for dividing the weight output of the adder 66 by the content of volume register 102 to obtain the apparent specific gravity, an RASG register 108 for storing a predetermined reference apparent
 105 specific gravity (RASG), a subtracter 110 for calculating the deviation of apparent specific gravity from the stored RASG, and a control circuit 112 for responding to this deviation to control the crusher 32. The above RASG is
 110 equal to the quotient of the content of lower threshold weight register 78 divided by the content of volume register 102.

U. S. Patent No. 4,385,671 and its continuation application Serial No. 443,959 filed
 120 November 23, 1982, or U. K. Patent No. 2,077,067 discloses a combination weighing machine of so-called "double-shift" type which operates such that, before the weighing units having participated in a specific combination and then been unloaded and loaded reach their stable states, respectively, the next combination is selected out from the remaining weighing units, thereby improving working efficiency of the machine. Now, the description will be made about another embodi-
 125 130

ment in which this invention is applied to this type of combination weighing machine, with reference to Fig. 5.

The circuit configuration of Fig. 5 is mostly similar to that of Fig. 3, while an inhibit circuit 114 is coupled between combination generator 72 and selective adder circuit 70 (and combination memory 76). The inhibit circuit 114 receives the weight signals from weight sensors $16_1, 16_2, \dots, 16_n$ to sense loading of specific weighing units from the values thereof and serves to inhibit high level signals from appearing at the corresponding outputs of the combination generator 72 for a predetermined time so that these weighing units do not participate in any combination until they become stable. Accordingly, before stabilization of the weighing units having participated in a combination and having unloaded and loaded again, the next combination operation can be initiated with the remaining weighing units. The inhibit circuit 114 may be actuated in response to the input signals of unloading devices $84_1, \dots, 84_n$ or loading devices $88_1, \dots, 88_n$ instead of the weight signals from sensors $16_1, \dots, 16_n$. Detailed configuration and operation of inhibit circuit 114 will not be described further, since they are described in the abovementioned U. S. or U. K. patent specification.

Further, in this embodiment, a single-pole, double-throw switch 116 is disposed in place of adder 66 of Fig. 1 and its fixed contacts a and b are coupled to the outputs of weight sensors 16_a and 16_b , respectively. The movable contact c of the switch 116 is coupled to one input of comparator 60 and to "0" input of selective adder circuit 70. The output of comparator 68 is coupled to the movable contact c of a second single-pole, double-throw switch 118, whose fixed contacts a and b are coupled through OR gates 82_a and 82_b , respectively, to unloading devices 84_a and 84_b , and whose movable contact c is coupled through an OR gate 82_c and delay element 86_c to loading device 88_c . The high level output terminal Q of memory 76 is coupled to the movable contact c of a third single-pole, double-throw switch 120 and to the other input of OR gate 82_c , and the fixed contacts a and b of the switch 120 are coupled respectively to the other inputs of OR gates 82_a and 82_b . The three single-pole, double-throw switches 116, 118 and 120 are turned concurrently in gang fashion in response to the output signal of delay element 86_c (or the input signal of loading device 88_c), in such fashion that, when the contact a of switch 116 is in use, the contacts a of switches 118 and 120 are also in use.

Assuming now that all switches are in their contacts a , it should be understood the circuit arrangement of Fig. 5 operates similarly to that of Fig. 3, using only constant volume weighing unit 10_a (without use of constant

volume weighing unit 10_b). In this condition, if the loading of the weighing units, which participated in the combination including weighing unit 10_a and have been unloaded, is initiated, the input signal of loading device 88_c turns switches 116, 118 and 120 to their contacts b at the same time. This results in removal of weighing units 10_a from the next combination and, in co-operation with the abovementioned inhibit circuit 114, the next combination operation can be started immediately with the remaining weighing units which did not participate in the combination. While all switches will return to their contacts a upon completion of the next combination operation, the weighing unit 10_a will be in its stable state already and be able to participate in the combination after next.

In the arrangement of Fig. 5, in contrast to that of Fig. 3, constant volume weighing units 10_a and 10_b must be loaded alternatively since they are used alternatively. This can be done, as shown in Fig. 7, the plan view of constant volume feeding device 18 from which top plate 46 and overlying components are removed, by making the number of volumetric holes 44 of volumetric disc 42 odd so that the volumetric holes register alternatively with holes 38_a and 38_b of bottom plate 36. The above-described constant volume feeding device 18 was given only for illustrative purposes and any other type of constant volume feeding device can be used for the device of this invention.

100

CLAIMS

1. A combination weighing machine, comprising
 - a) first weighing unit or units for weighing product of allowable minimum volume by a single unit or separately by plural units to produce a first weight signal of the product of allowable minimum volume, as a sum,
 - d) second weighing units for weighing product of arbitrary small volume as compared with the former volume to produce a plurality of second weight signals,
 - c) arithmetic means for combining said first and second weight signals in various fashion to select a combination the sum of which satisfies a predetermined weight condition,
 - b) means for unloading and newly loading said first and second weighing units belonging to said selected combination;
- 120 wherein said machine further comprises
 - e) means for unloading and newly loading only said first weighing unit or units when said first weight signal satisfies said predetermined weight condition, and
 - f) means for actuating said arithmetic means and unloading and newly loading the weighing units belonging to the selected combination when said first weight signal does not satisfy the predetermined weight condition.

2. A combination weighing machine, comprising

- a) a pair of first weighing units for weighing product of allowable minimum volume to produce a first weight signal each,
- b) second weighing units for weighing product of arbitrary small volume as compared with the former volume to produce a plurality of second weight signals,
- c) arithmetic means for combining in various fashion one or the other of said first weight signals and said second weight signals to select a combination the sum of which satisfies a predetermined weight condition,
- d) means for unloading and newly loading said first and second weighing units belonging to the selected combination;
- wherein said machine further comprises
- e) means for unloading and newly loading either of first weighing units when the corresponding first weight signal satisfies the predetermined weight condition,
- f) means for actuating said arithmetic means and unloading and newly loading the weighing units belonging to the selected combination when said first weight signal does not satisfy the predetermined weight condition,
- g) means responsive to the unloading and loading of the second weighing units selected in the preceding cycle for inhibiting only said weighing units from participating in the new combination operation for a predetermined time during actuation of said arithmetic means.

3. A product feeding device for the combination weighing machine according to Claim 1 or 2, comprising a constant volume feeding device for feeding product of allowable minimum volume, a divider for dividing the weight signal of said first weighing unit by the fed volume of one doze to calculate the apparent specific gravity, and an indicator for indicating said apparent specific gravity.

4. A product feeding device according to Claim 3, comprising a crushing device for crushing said product, and control means for controlling said crushing device based upon said first weight signal or said apparent specific gravity.

5. A method of delivering quantities of product with each quantity satisfying predetermined weight and volume conditions, utilizing a single or plurality of first weighing unit or units and a plurality of second weighing units each adapted for unloading of product therefrom to contribute to a delivery, said method comprising for each delivery the steps of:

- a) weighing product of allowable minimum volume by said first weighing unit or units to produce a first weight signal of said product of allowable minimum volume as a sum and, at the same time, weighing product of arbitrary small volume as compared with the former volume by each of said second weighing

units to produce a plurality of second weight signals,

- b) unloading and newly loading said first weighing unit or units when said first weight signal satisfies said predetermined weight condition,

- c) combining said first and second weight signals in various fashion to select a combination the sum of which satisfies said predetermined weight condition and then unloading and newly loading said first and second weighing units belonging to said selected combination, when said first weight signal does not satisfy said predetermined weight condition.

6. A method of delivering quantities of product with each quantity satisfying predetermined weight and volume conditions, utilizing a pair of first weighing units and a plurality of second weighing units each adapted for unloading of product therefrom to contribute a delivery, said method comprising for each delivery the steps of:

- a) weighing product of allowable minimum volume by one or the other of said first weighing units to produce a first weight signal and, at the same time, weighing product of arbitrary small volume as compared with the former volume by said second weighing units to produce a plurality of second weight signals,
- b) unloading and newly loading said first weighing unit when said first weight signal satisfies said predetermined weight condition, and

- c) combining said first and second weight signals in various fashion to select a combination the sum of which satisfies said predetermined weight condition and then unloading and newly loading said first and second weighing units belonging to said selected combination, when said first weight signal does not satisfy said predetermined weight condition,

wherein, for each delivery, said first weighing units are switched from one to the other and the combining step is carried out before the weighing units which were unloaded on the preceding delivery are loaded again and reach stabilization.